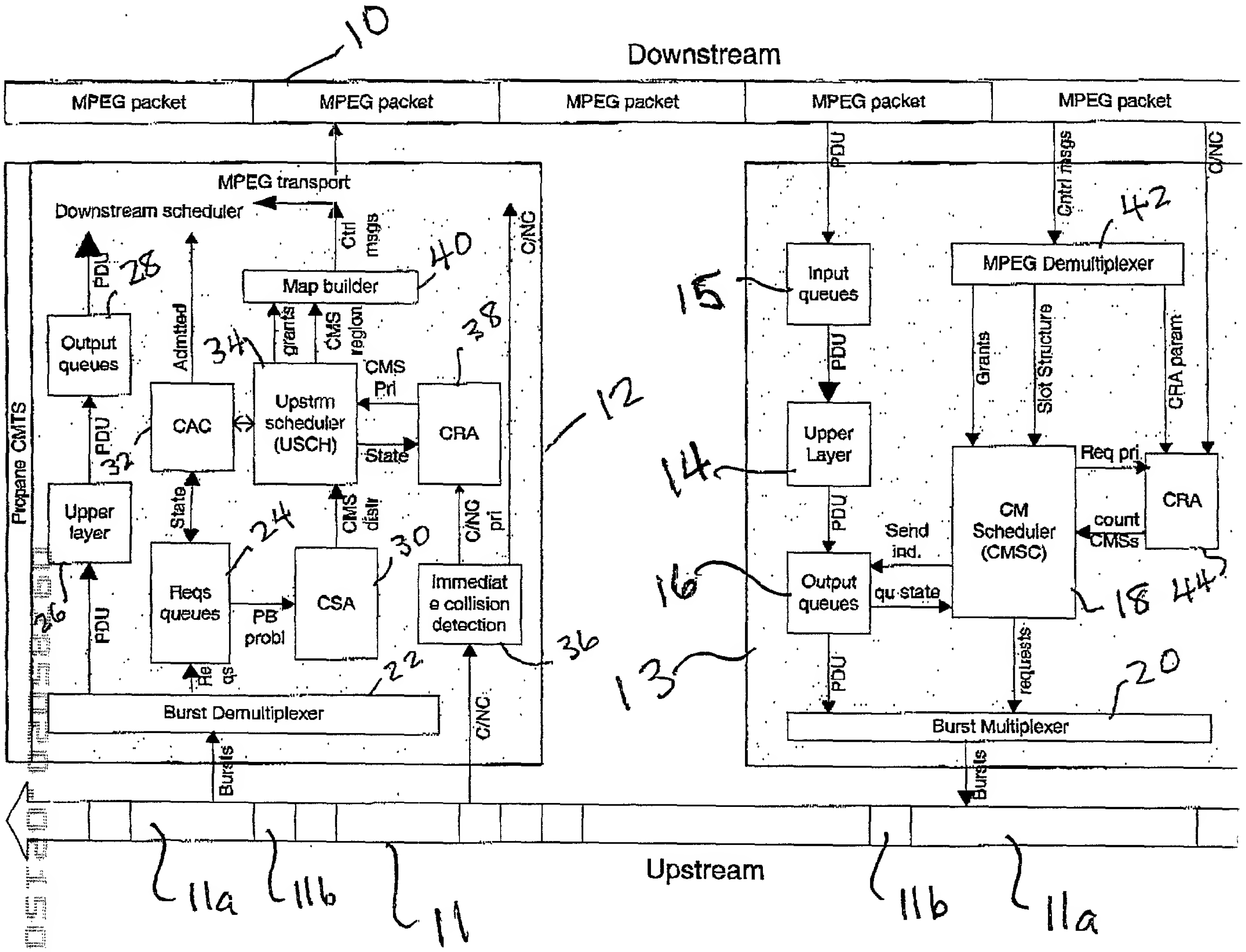
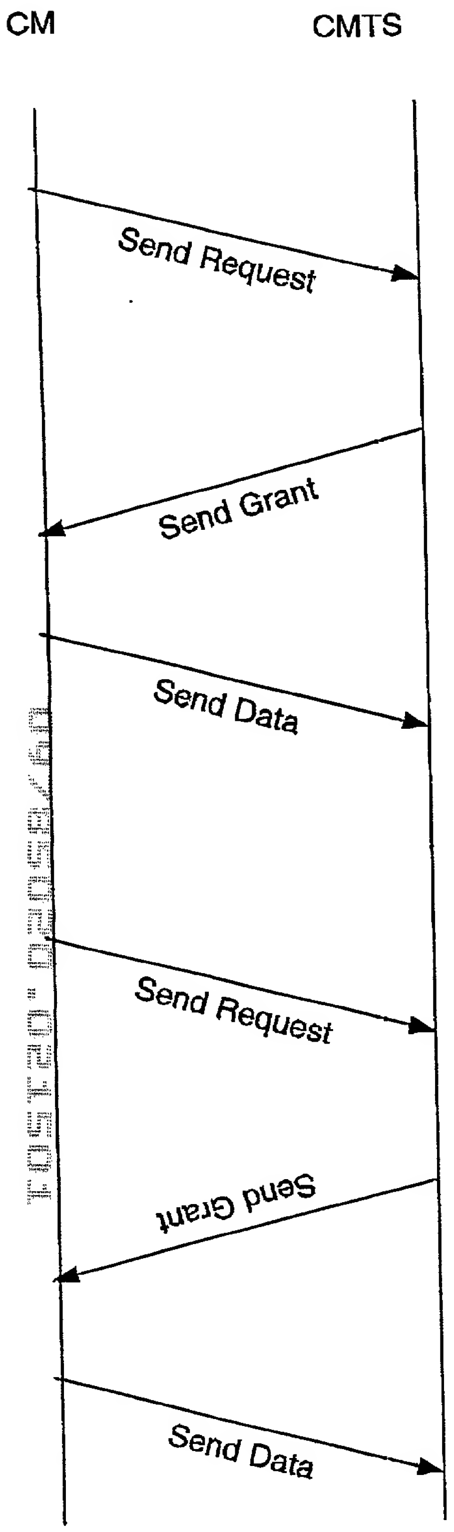
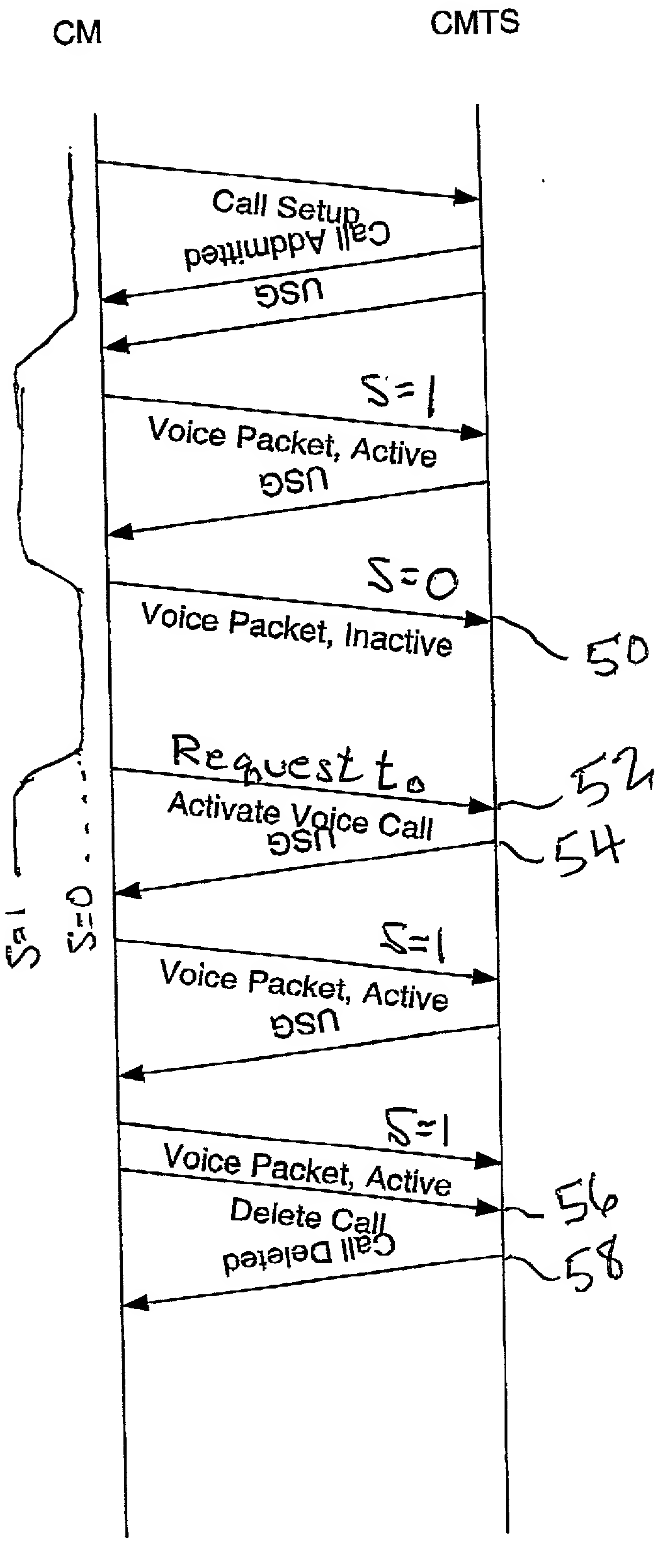

10
Downstream
MPEG packet
MPEG packet
MPEG packet
MPEG packet
MPEG packet
Propane CMTS
MPEG transport
Downstream scheduler
Ctrl msgs
C/NC
PDU
28
Map builder
40
Output queues
Admitted
34
grants
CMS region
CMS Pri
38
CAC
Upstrm scheduler (USCH)
CRA
State
12
PDU
32
Upper layer
State
24
CMS distr
C/NC pri
30
Reqs queues
PB probl
CSA
Immediate collision detection
26
PDU
Re qs
22
36
Burst Demultiplexer
C/NC
Bursts
PDU
Cntrl msgs
C/NC
42
15
Input queues
MPEG Demultiplexer
PDU
Grants
Slot Structure
CRA param
Upper Layer
Req pri.
14
CM Scheduler (CMSC)
CRA
PDU
Send ind.
count CMSs
16
Output queues
qu state
18
44
requests
13
PDU
20
Burst Multiplexer
Bursts
11a
11b
11
Upstream
11b
11a

FIG. 1



Data Service

FIG. 2A



Voice Service

FIG. 2B

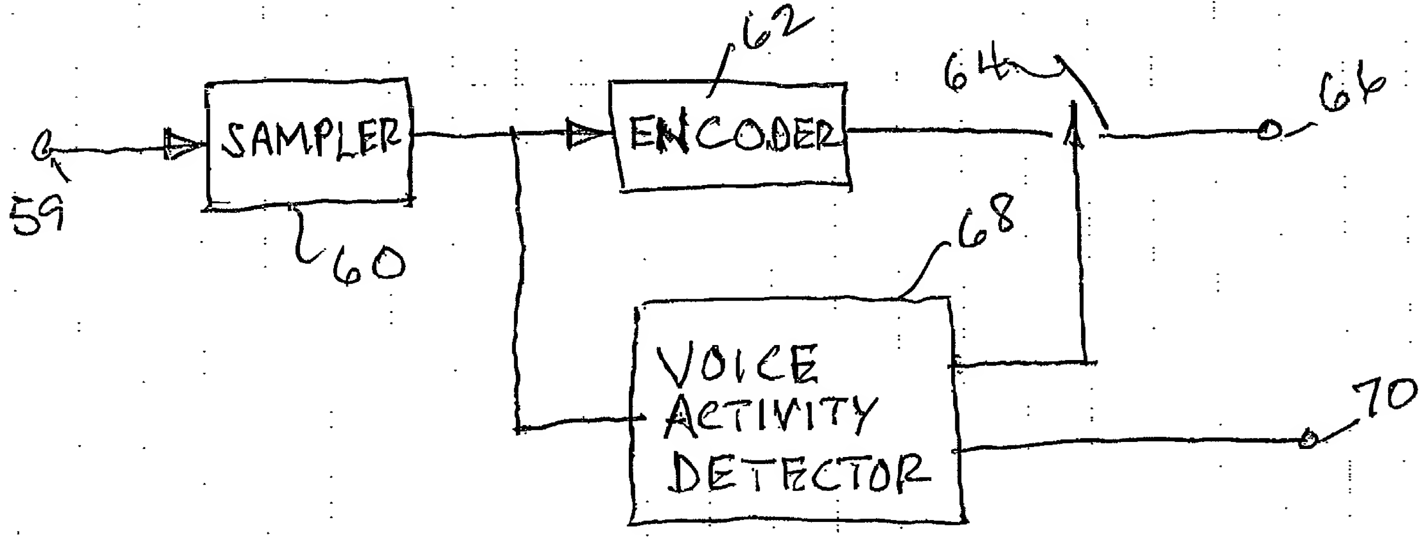


FIG. 3

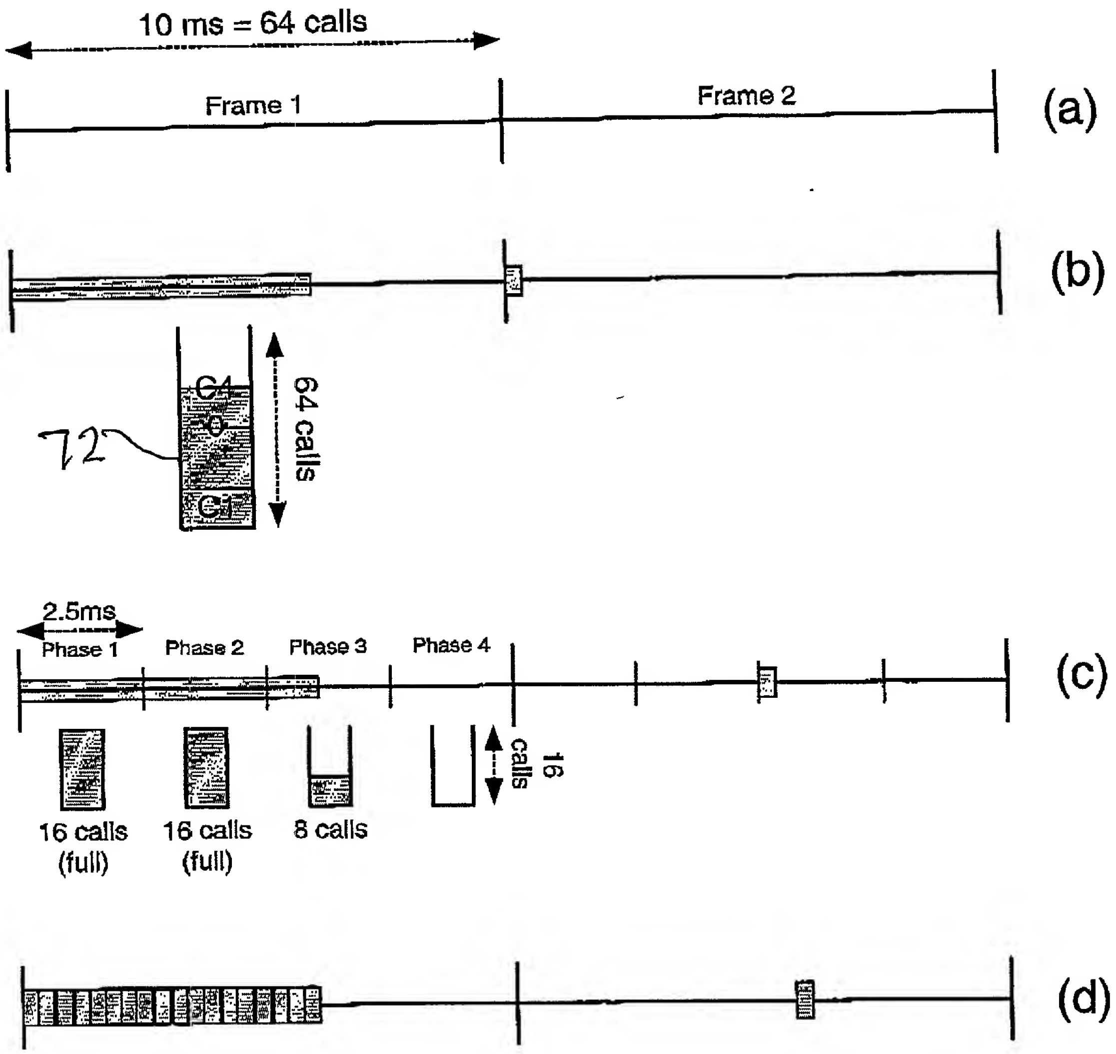

10 ms = 64 calls
Frame 1
Frame 2
(a)
(b)
C4
C1
72
64 calls
2.5ms
Phase 1
Phase 2
Phase 3
Phase 4
(c)
16 calls (full)
16 calls (full)
8 calls
16 calls
(d)

FIG. 4

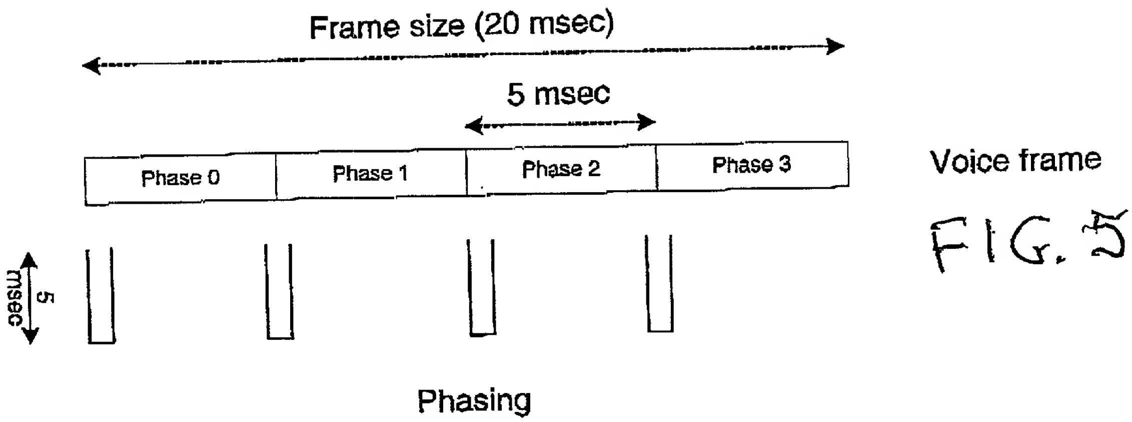


FIG. 5A

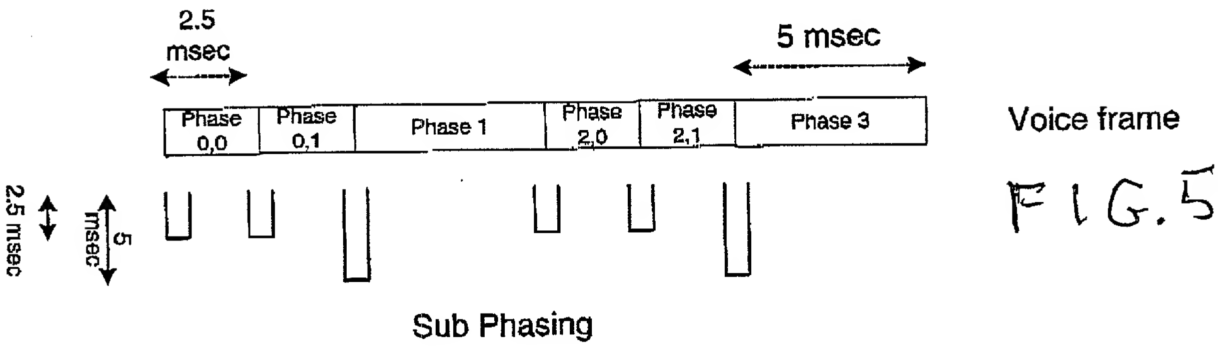
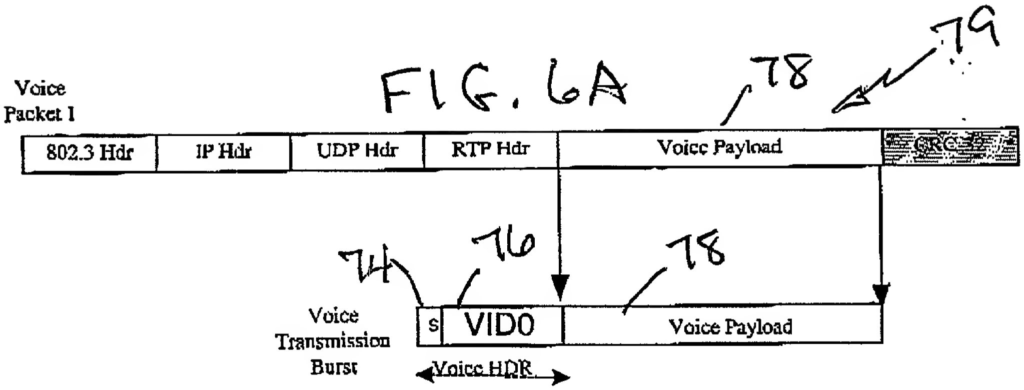


FIG. 5B

FIG. 5C

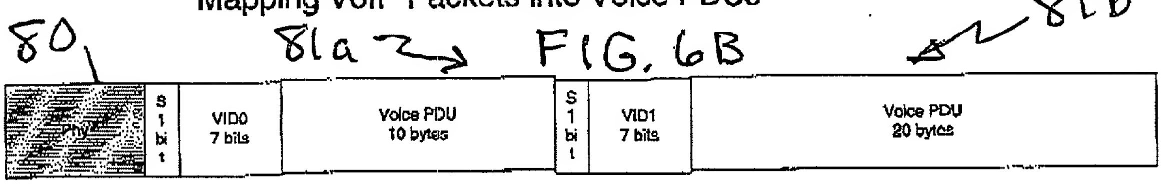
Call 1 : CM1, VID0: 5ms, 16 Kbps = 2 MS (1:0)
Call 2 : CM2, VID0: 10ms, 32 Kbps = 4 MS (2:0)
Call 3: CM3, VID0: 20ms, 32 Kbps = 7 MS (3:0)
Call 4: CM4, VID0: 20ms, 32 Kbps = 7 MS (4:0)
Call 5: CM1, VID1: 10ms, 16 Kbps = 3 MS (1:1)
Call 6: CM2, VID1: 10ms, 16 Kbps = 3 MS (2:1)

FIG. 6A



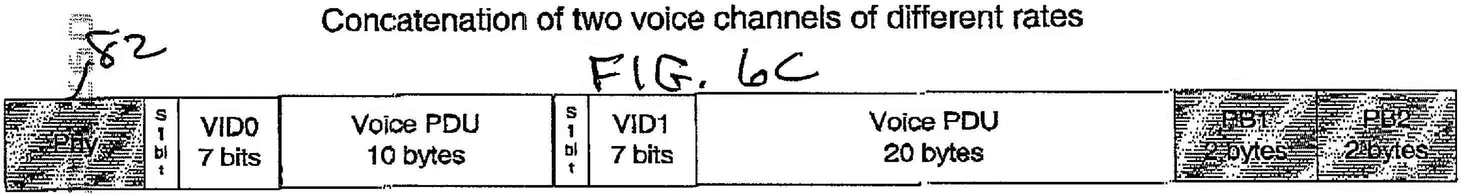
Mapping VoIP Packets into Voice PDUs

FIG. 6B



Concatenation of two voice channels of different rates

FIG. 6C



Concatenation of voice channels and piggybacking requests

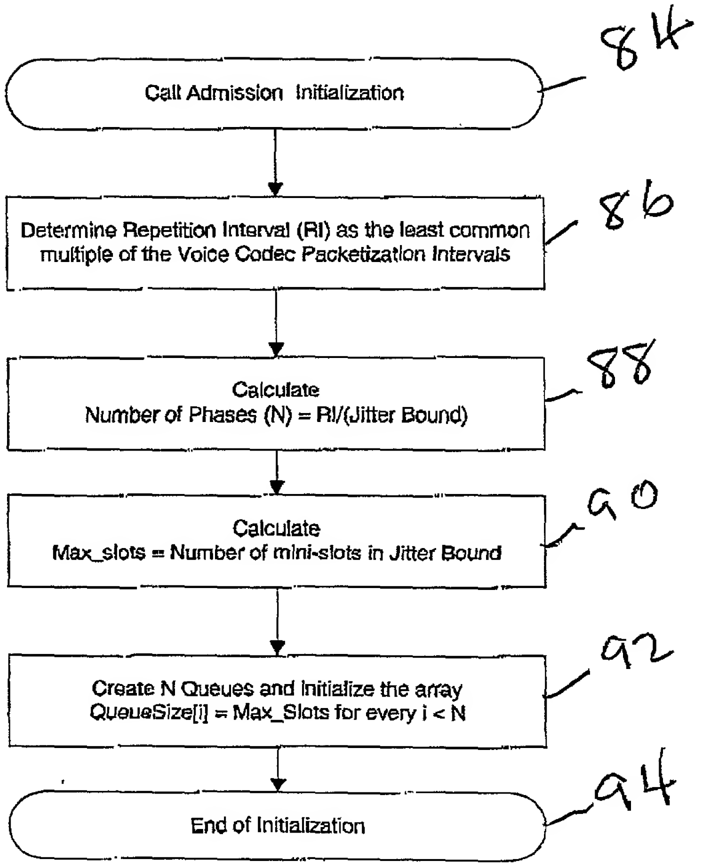

Call Admission Initialization
84
Determine Repetition Interval (RI) as the least common multiple of the Voice Codec Packetization Intervals
86
Calculate Number of Phases (N) = RI/(Jitter Bound)
88
Calculate Max_slots = Number of mini-slots in Jitter Bound
90
Create N Queues and initialize the array QueueSize[i] = Max_Slots for every i < N
92
End of Initialization
94

FIG. 7

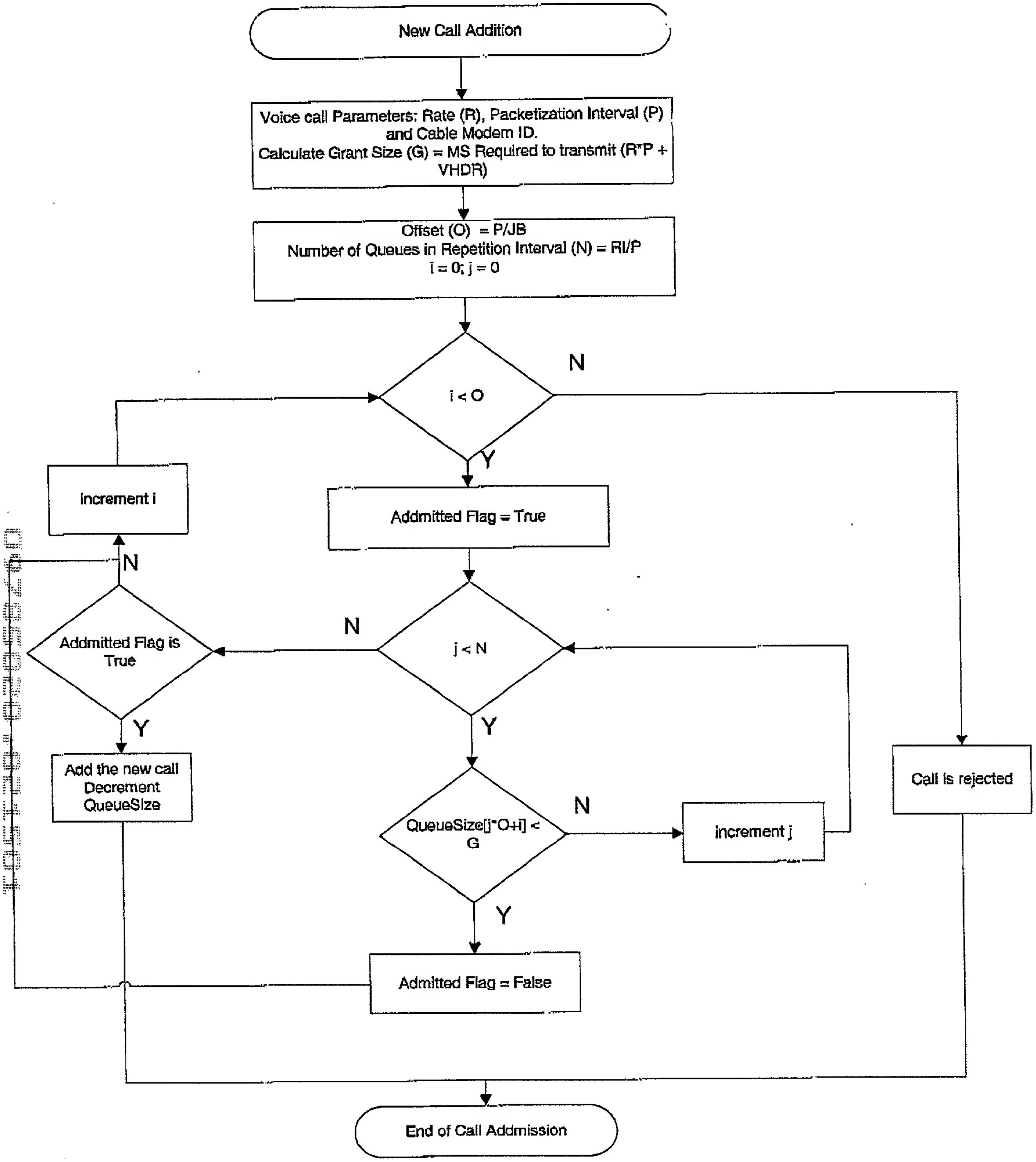
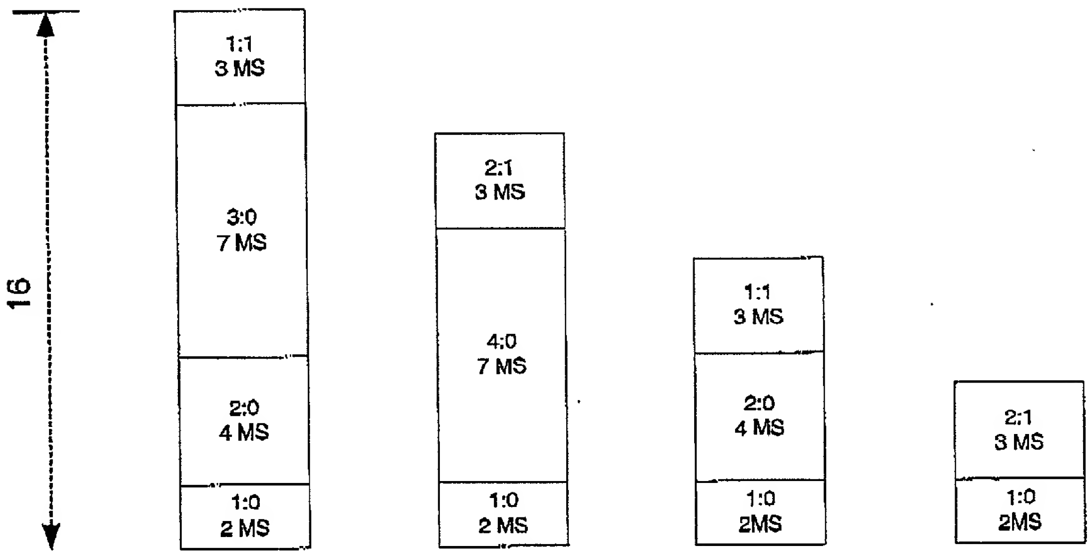
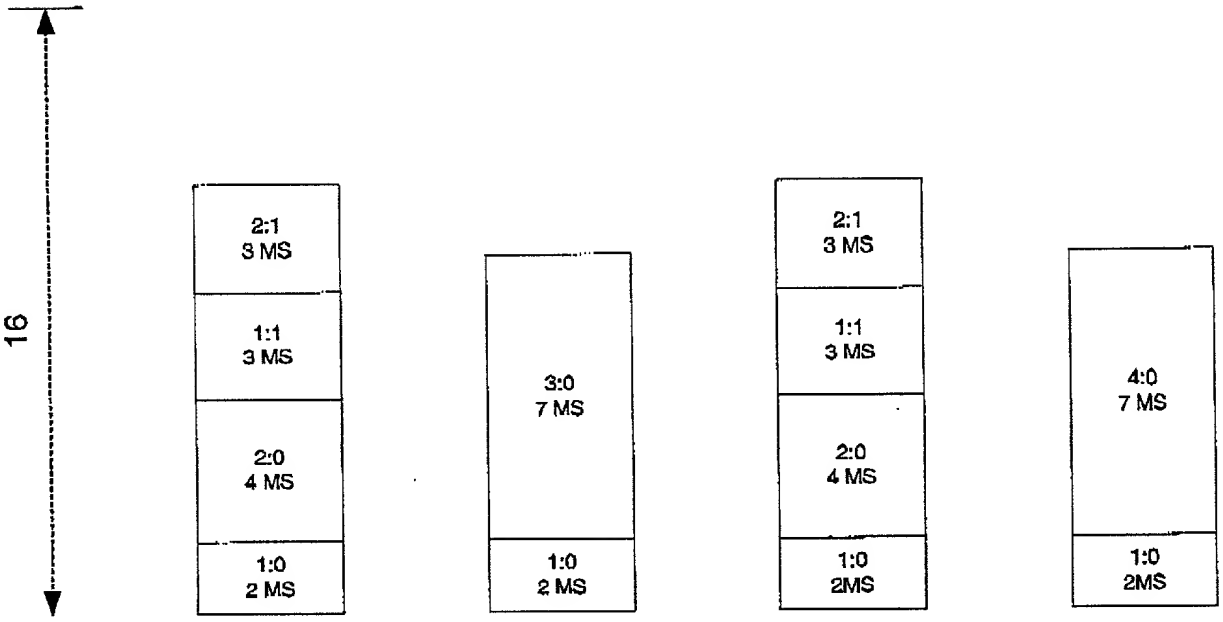

New Call Addition
Voice call Parameters: Rate (R), Packetization Interval (P) and Cable Modem ID.
Calculate Grant Size (G) = MS Required to transmit (R*P + VHDR)
Offset (O) = P/JB
Number of Queues in Repetition Interval (N) = RI/P
i = 0; j = 0
i < O
N
Y
Increment i
Addmitted Flag = True
N
Addmitted Flag is True
N
j < N
Y
Y
Add the new call Decrement QueueSize
QueueSize[j*O+i] < G
N
increment j
Call is rejected
Y
Admitted Flag = False
End of Call Addmission

FIG. 8



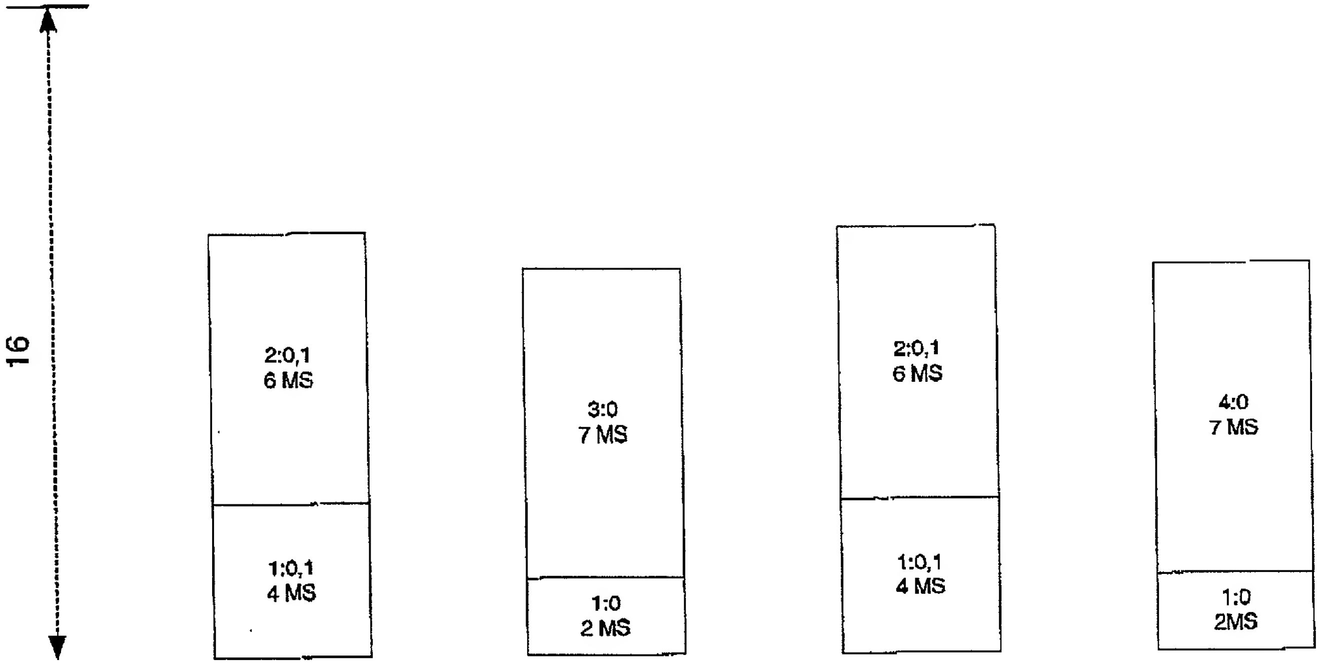
Call Admission: Unbalanced

FIG. 9



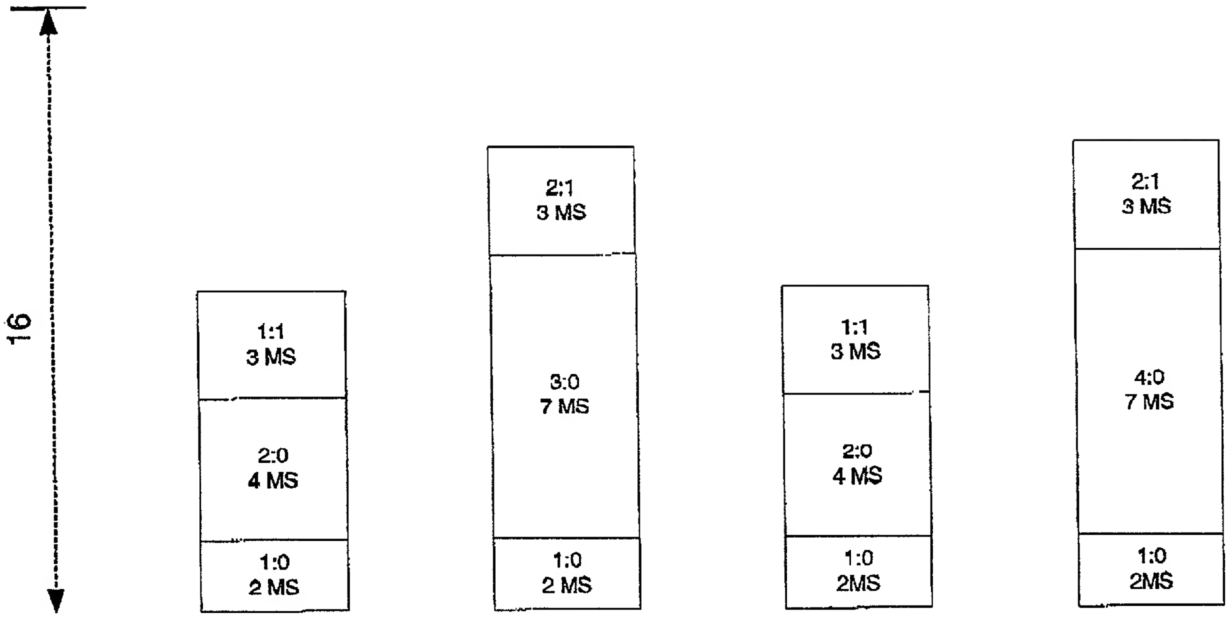
Call Admission: Balanced

FIG, 10



Call Admission: Balanced with Concatenation

FIG. 11



Call Admission: Balanced and Distributed CM Allocation

FIG. 12

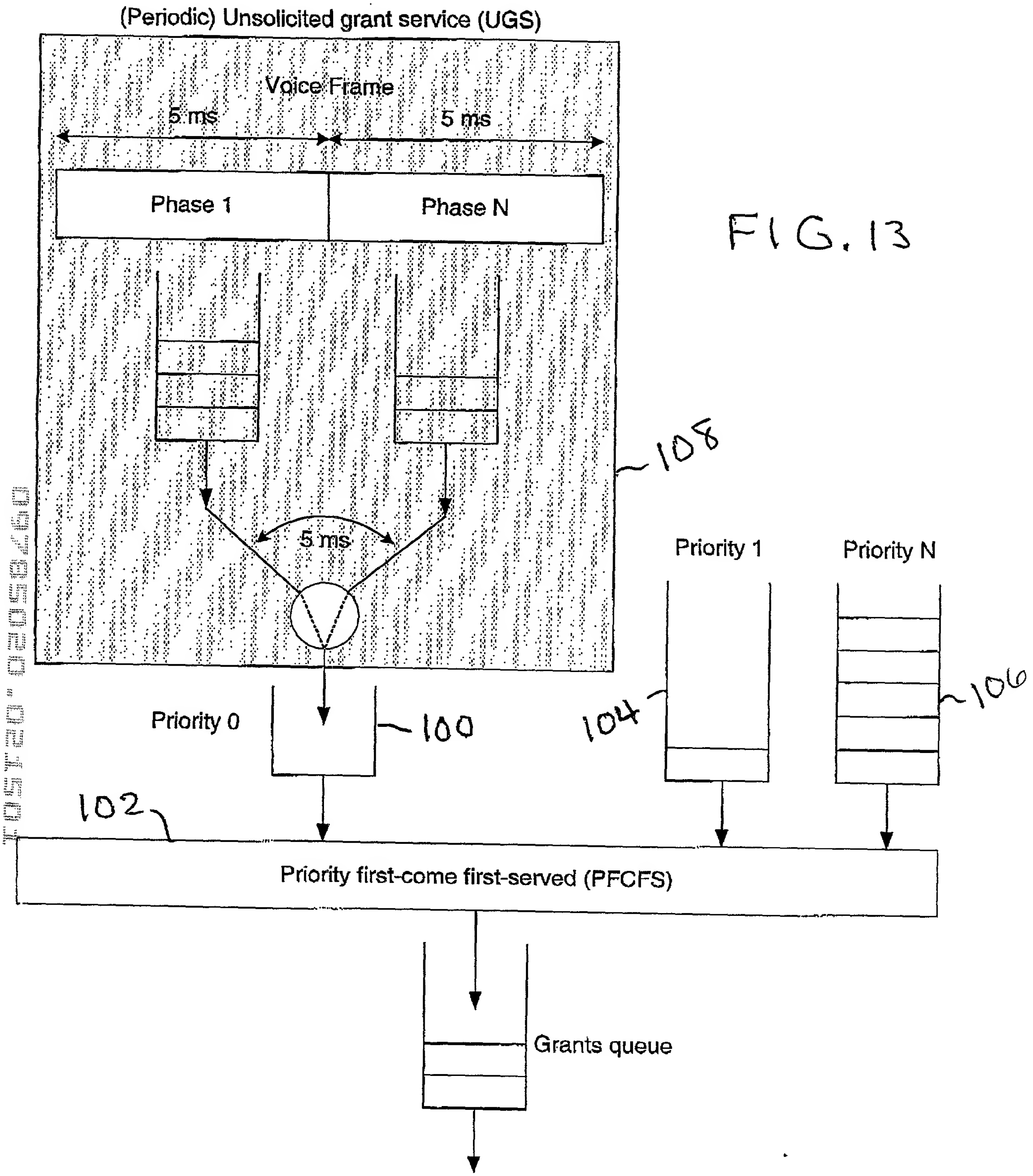

(Periodic) Unsolicited grant service (UGS)
Voice Frame
5 ms
5 ms
Phase 1
Phase N
108
5 ms
Priority 1
Priority N
Priority 0
100
104
106
102
Priority first-come first-served (PFCFS)
Grants queue

FIG. 13

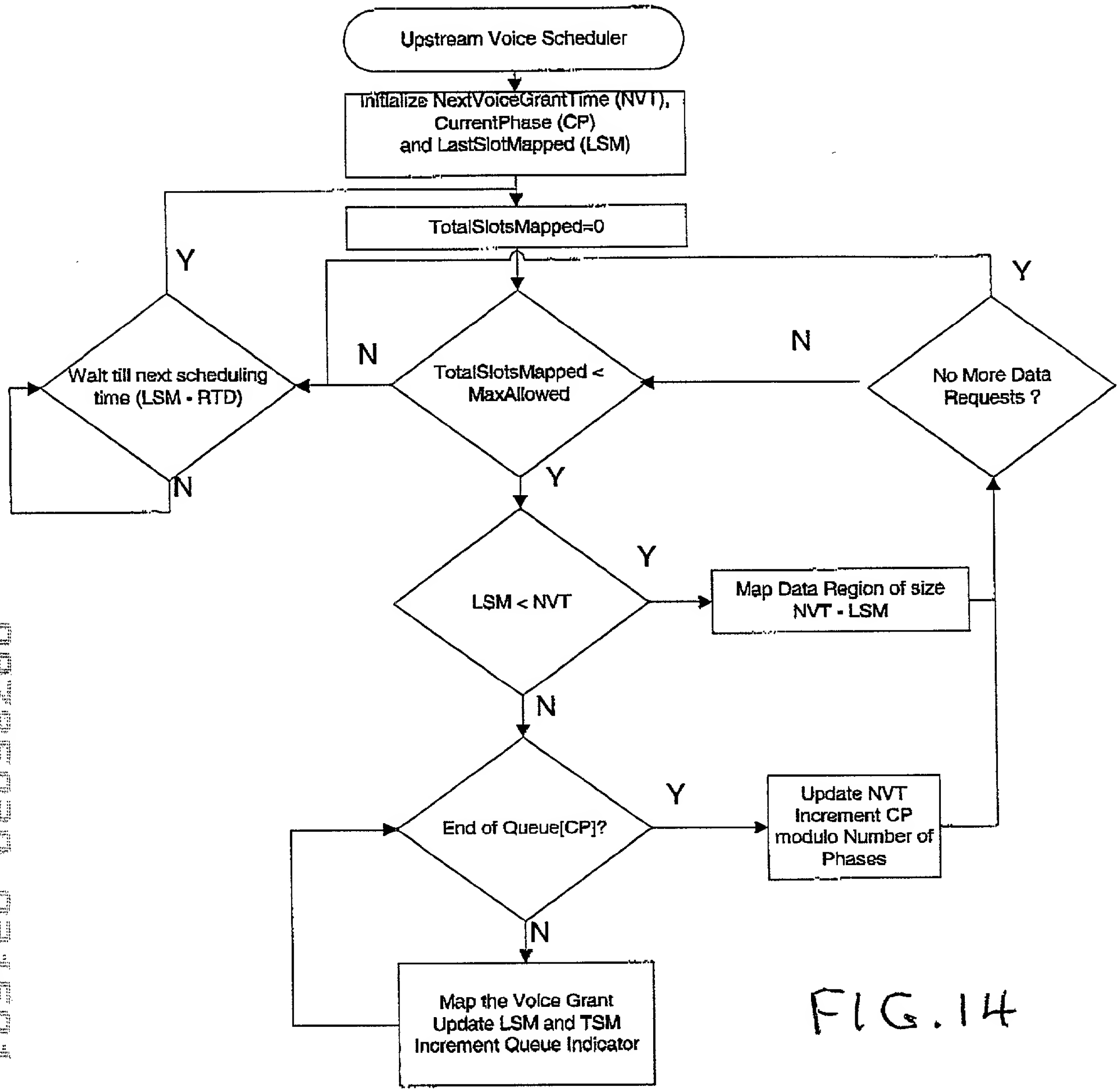
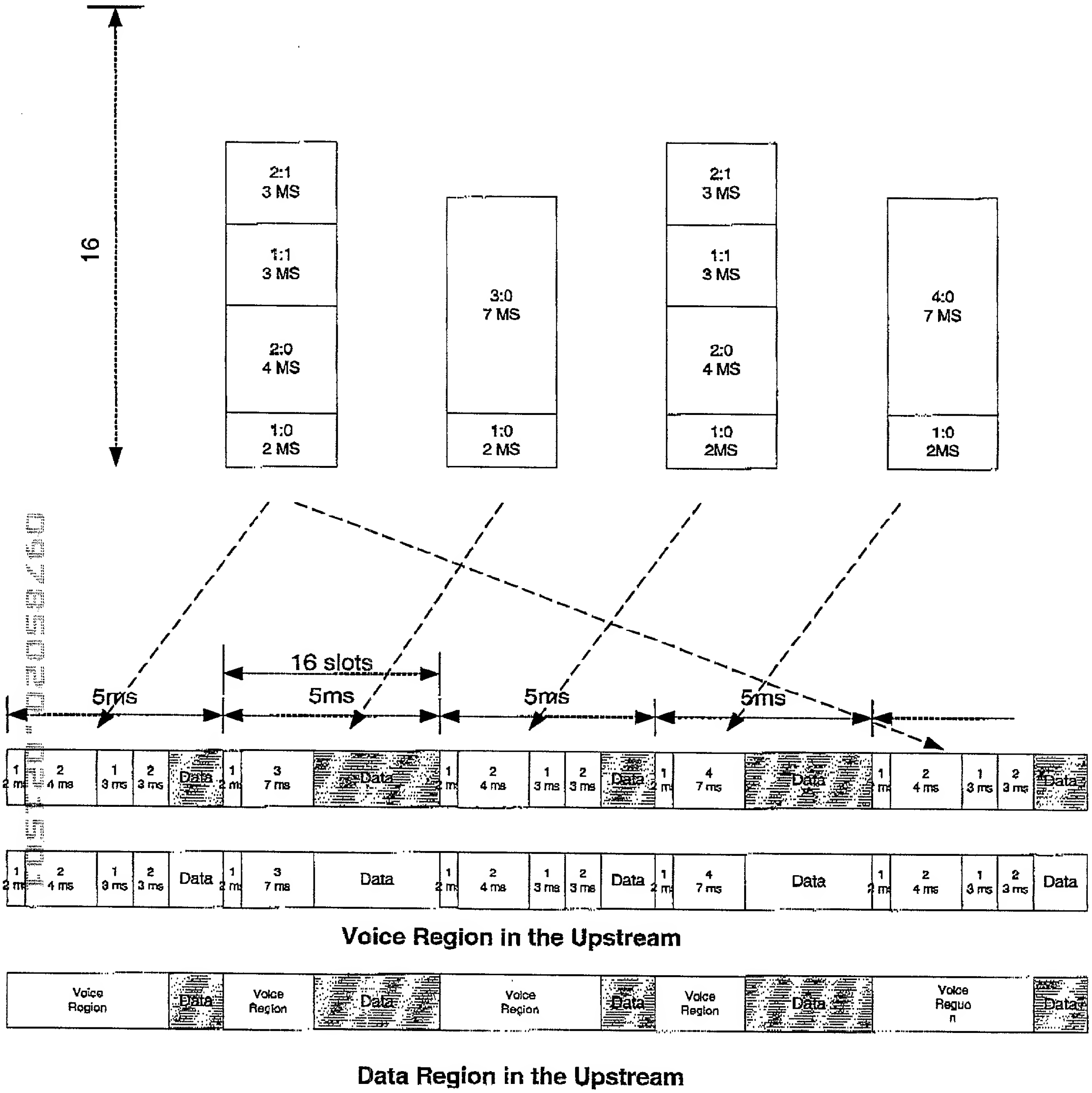
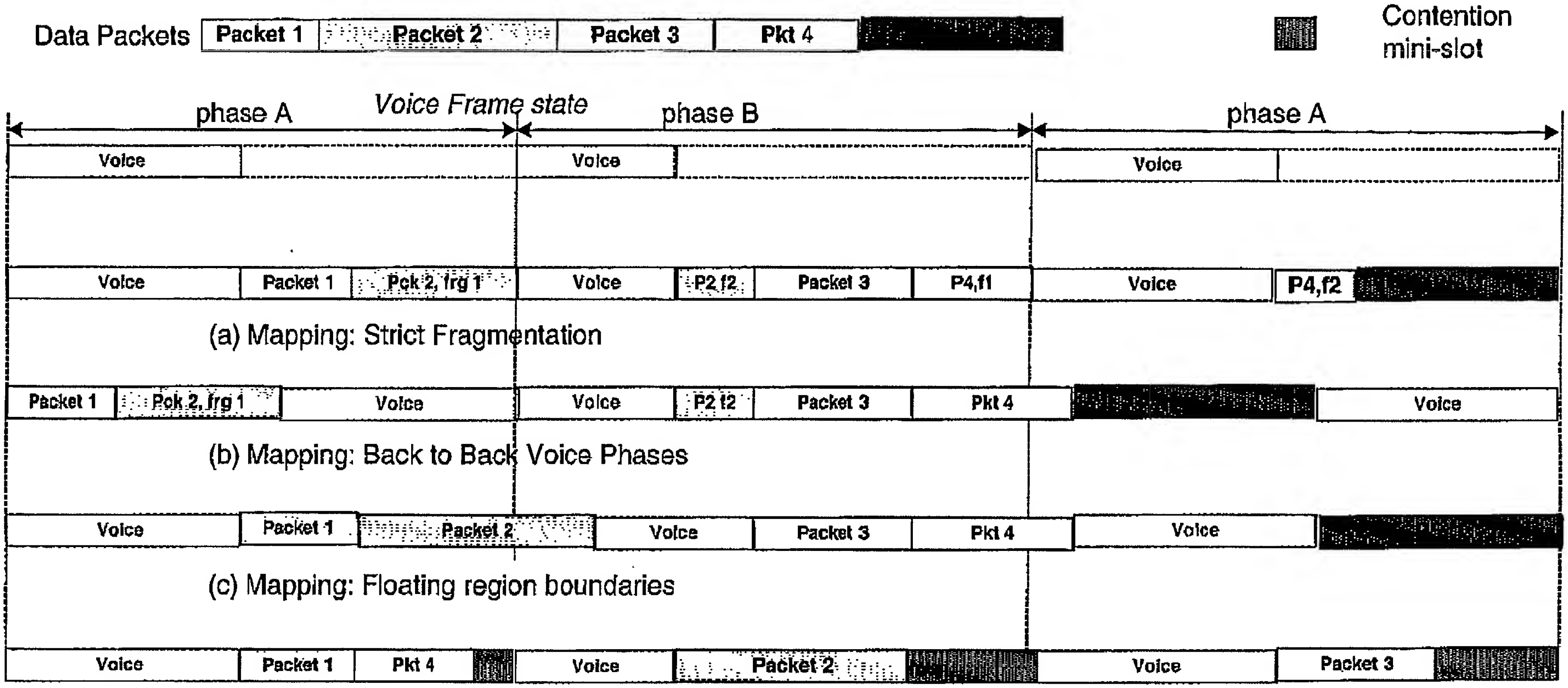

Upstream Voice Scheduler
Initialize NextVoiceGrantTime (NVT), CurrentPhase (CP) and LastSlotMapped (LSM)
TotalSlotsMapped=0
Y
Wait till next scheduling time (LSM - RTD)
N
N
TotalSlotsMapped < MaxAllowed
N
Y
No More Data Requests ?
Y
LSM < NVT
Y
Map Data Region of size NVT - LSM
N
End of Queue[CP]?
Y
Update NVT Increment CP modulo Number of Phases
N
Map the Voice Grant Update LSM and TSM Increment Queue Indicator

FIG. 14



Voice Scheduling : Mapping Voice State into Upstream Grants

FIG. 15



(a) Mapping: Strict Fragmentation

(b) Mapping: Back to Back Voice Phases

(c) Mapping: Floating region boundaries

(d) Mapping: Fixed region boundaries: best fit (No Fragmentation)

FIG. 16

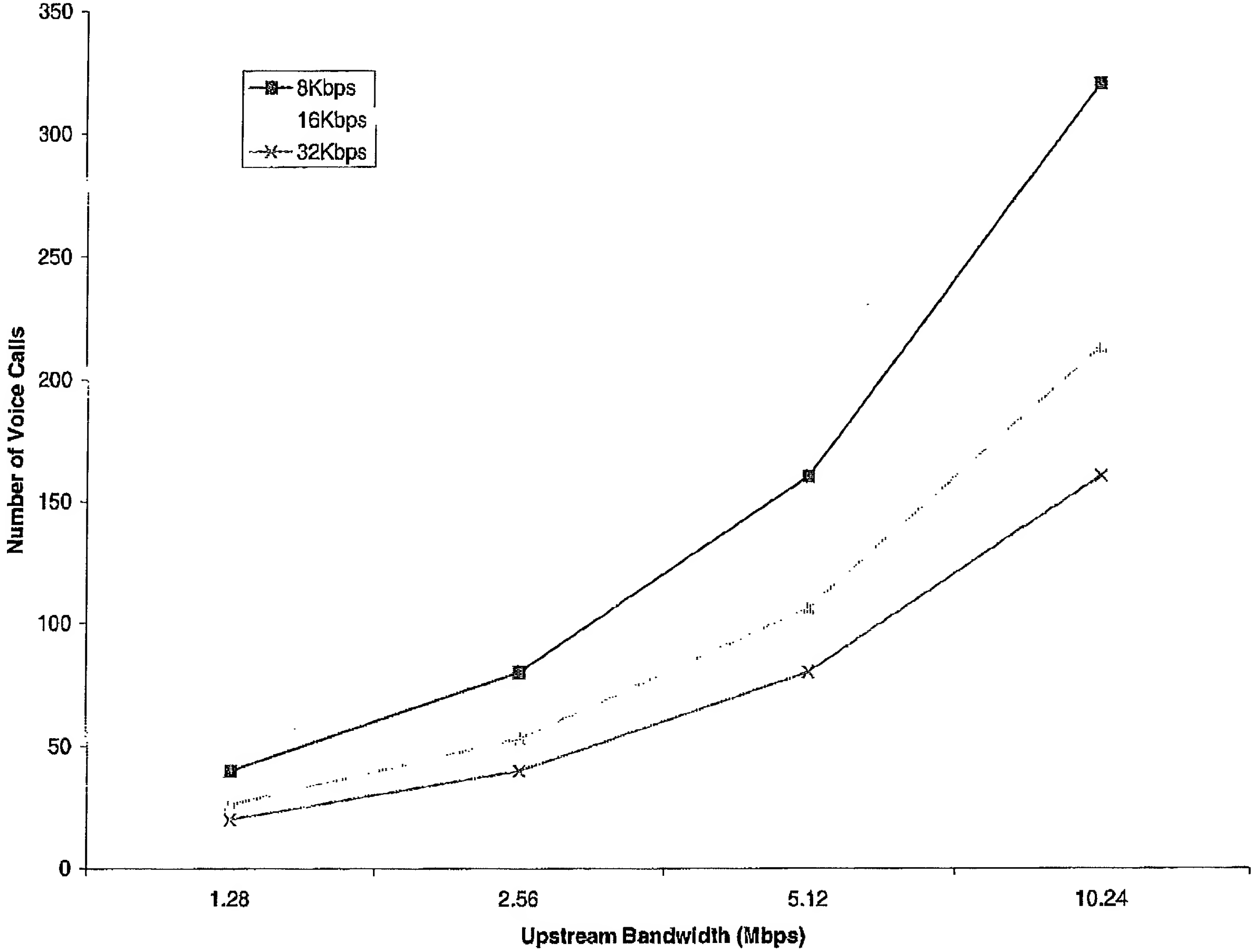

8Kbps
16Kbps
32Kbps
Number of Voice Calls
350
300
250
200
150
100
50
0
1.28
2.56
5.12
10.24
Upstream Bandwidth (Mbps)

FIG. 17

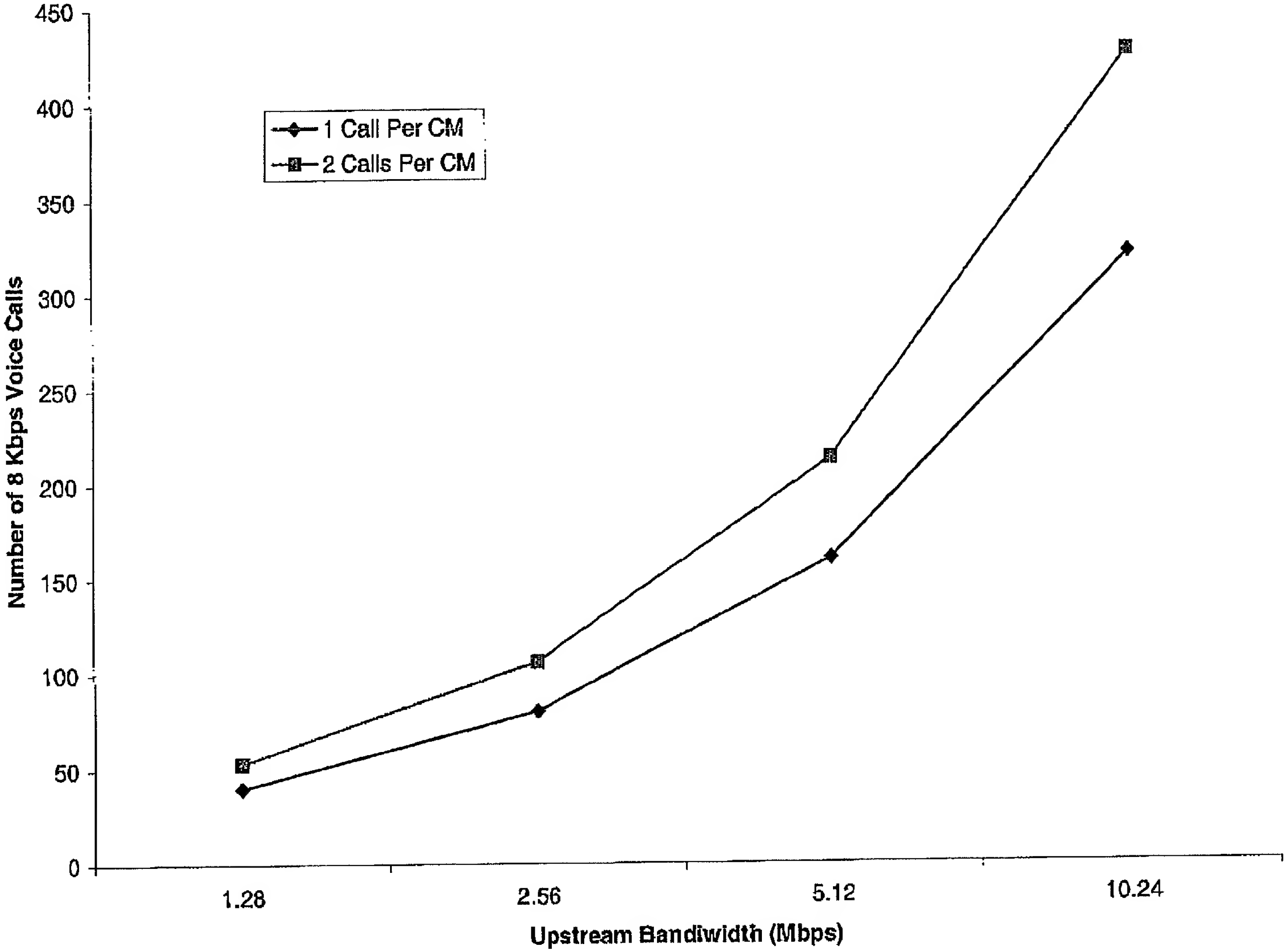

450
400
350
300
250
200
150
100
50
0
Number of 8 Kbps Voice Calls
1 Call Per CM
2 Calls Per CM
1.28
2.56
5.12
10.24
Upstream Bandiwidth (Mbps)

FIG. 18

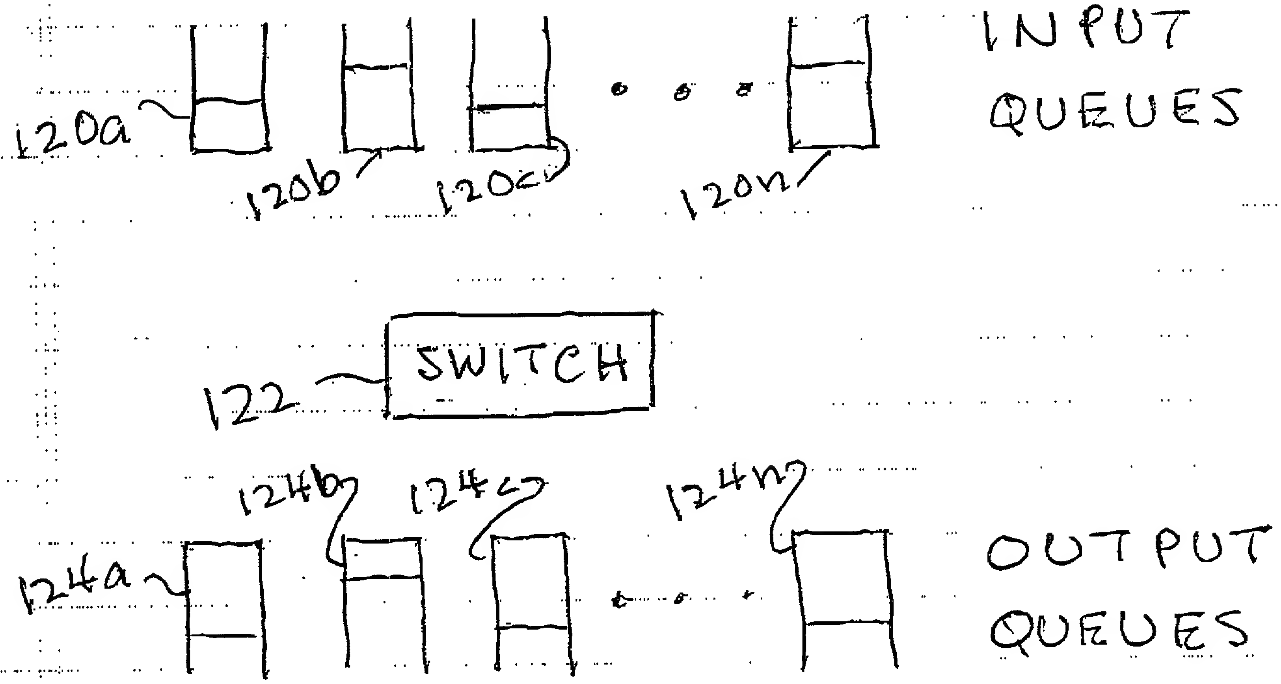

INPUT
QUEUES
120a
120b
120c
120n
122
SWITCH
124a
124b
124c
124n
OUTPUT
QUEUES

FIG. 19